EFFECT OF CHEMICAL TREATMENT ON THE ELECTRICAL CONDUCTIVITY OF GRAPHITE

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Recently it has been shown by Ray (1959) that the usual purificatory treatments of the naturally occurring crystals of graphite for measuring their different properties, cause an easily detectable enhancement of the small amount of misalignment originally present between the basal planes of the different crystal blocks. It is also observed that most of the earlier measurements on the electrical conductivities of graphite (Krishnan and Ganguly, 1939; Dutta, 1953: Primak and Fuchs 1954) were with crystals which had been purified in the usual way. Investigations have therefore been undertaken to study the effect, if any, of such treatments on the electrical conductivities of graphite. Results of measurements on three different samples of Ceylon graphite are shown in the table below.

TABLE 1

Crystal	Before Treatment			After Treatment			$\frac{\Delta\sigma_{\parallel}}{\sigma_{\parallel}}\times 100$	$\frac{\Delta\sigma_{\perp}}{\sigma_{\perp}}\times 100$
	$\sigma_{\parallel}$ Conductivity $\parallel$ to c-axis	$\sigma_{\perp}$ Conductivity $\perp^r$ to c-axis	$\frac{\sigma_{\perp}}{\sigma_{\parallel}}$	$\sigma_{\parallel}'$ Conductivity $\parallel$ to c-axis	$\sigma_{\perp}'$ Conductivity $\perp^r$ to c-axis	$\frac{\sigma_{\perp}'}{\sigma_{\parallel}'}$		
1	.068	$.805\times10^{4}$	11.84×10^{1}	.216	581×10^{1}	2.69×10^{4}	182.8	−38.4
2	.077	$.529\times10^{4}$	6.91×10^{4}	.217	$.327\times10^{4}$	1.51×10^{1}	183.0	−38.2
3	.089	$.371\times10^{4}$	4.14×10^{4}	.254	$.232\times10^{4}$	0.91×10^{1}	183.2	−37.6

It is observed that the conductivity perpendicular to the c-axis (along the basal plane) decreases appreciably while that along the c-axis increases considerably. This is easily explained on the basis of the findings of Ray (l.c.), who showed, as stated above, that the basal plane of the different crystal blocks orient due to such treatments randomly about directions in the basal plane. As a result, the observed conductivities in the two directions will be the resultants of the

components in these directions of the actual conductivities along and perpendicular to the *c*-axis corresponding to any oriented crystal block summed up for all such blocks. The conductivity along directions perpendicular to the *c*-axis being very much greater than that along the *c*-axis (Krishnan and Ganguly, 1939; Dutta, 1953; Primak and Fuchs, 1954), the decrease and increase of conductivities perpendicular and along the *c*-axis respectively, as observed experimentally (table above), is therefore quite obvious It is to be noted in consequence that neither the earlier measurements (l.c.) on the electrical conductivities of graphite nor the present ones with untreated crystals represent the true conductivities of ideal graphite due respectively to the defects created and to defects originally present (Ray, l.c.). Therefore the observed difference between the results of the present measurements and the earlier ones* as also between the values of the conductivities of the different crystals of the present investigation are now easily understood. Evidently the X-ray tests of perfectness of the crystals as employed by earlier workers (l.c.) do not appear to be so carefully done as by Ray (l.c.).

Now in view of what has been stated above, the temperature variation of the conductivities, magneto-resistance effect, Hall effect, magnetic properties, etc. many of which are for treated samples (Dutta, 1953; Krishnan, 1953, Berlincourt *et al*, 1955; Soule, 1956) also do not represent the true behaviour of ideal graphite crystals. Large number of theoretical attempts (McClure, 1956, 1957, Haering and Wallace, 1957; Lifshitz *et al*, 1956; Lomer, 1955; Johnston, 1955, 1956; Nozières, 1958; Mase, 1958, etc.) have also recently been made to obtain a reasonable electronic picture of graphite based on the above experimental results. In order, therefore, to reassess these theories in view of the present findings, it is necessary to undertake to remeasure the above properties first with untreated natural crystals of graphite and then by producing defects artificially in them by the usual purificatory and other treatments, so as to be able to arrive at the true properties of ideal graphite crystals.

Details of some of these investigations will be published elsewhere shortly.

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*These differences in the values of $\sigma_{\parallel}$ of the present and earlier measurements might be also due to differences in the methods of measuring the *c*-axis conductivity. Investigations to decide this point are in progress.

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